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Psychological Monographs: General and Applied

Absolute and Relational Stimulus Training in Discrimination Learning[1,2]

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I. Introduction

A. *Viewpoints Regarding the Nature of Discrimination Learning*

The differential reactions of animals to stimuli differing quantitatively from each other along a particular dimension have long and often been regarded as a function of the relational nature of the stimulus situation. Among the early investigators in the field, Kinnaman in 1902 (8), Casteel in 1911 (2), Bingham in 1913 (1), and Coburn in 1914 (3), suggested that in discrimination problems, the animal may learn to respond to the relational characteristics of the stimulus situation rather than to the specific properties of each stimulus object. Although these researchers worked and published their statements before the development of gestalt psychology, this notion is generally regarded as a contribution of that school. Köhler is frequently credited with being the modern proponent of the concept, which is traced back to an article on brightness discrimination in chicks that was published in 1918 (9). More recently Lashley (12), Gulliksen and Wolfle (4, 5), Krechevsky (10), and Lashley and Wade (13) have advocated this concept.

Several other psychologists have been critical of the relational interpretation. Among these are Gundlach and Herington (6), Taylor (18), Warden and Rowley (19), and Warden and Winslow (20). But very few of the critics have proposed constructive alternative interpretations. An exception has been Spence, who has developed a theoretical scheme based on stimulus-response principles and concepts (16, 17). Spence's theory and that of Hull (7) are in many respects very similar.

According to Spence's hypothesis, in his own words:

> . . . discrimination learning is conceived as a cumulative process of building up the strength of the excitatory tendency of the positive stimulus cue (*i.e.*, the tendency of this stimulus to evoke the response of approaching it) by means of the successive reinforcements of the responses to it, as compared with the excitatory strength of the negative stimulus, responses to which receive no reinforcements (17, p. 431).

[1] This monograph is based on a dissertation submitted to the University of Michigan in partial fulfillment of the requirements for the degree of Doctor of Philosophy, August, 1951.

[2] A summary of this investigation was presented at the 1953 convention of the Midwestern Psychological Association in Chicago.

[3] The writer wishes to express his thanks to Professors Carl R. Brown, Lee R. Dice, Donald G. Marquis, Burton D. Thuma, and Dr. Donald W. Lauer, members of the doctoral committee, for their helpful criticisms and suggestions, and especially to Professor John F. Shepard, the chairman of the committee, who gave generously of his time, suggestions, criticisms, and encouragement throughout the planning and accomplishment of the research. The author also wishes to thank Dr. Herbert S. Conrad and Dr. John F. Dashiell whose constructive criticisms in the preparation of the present manuscript have resulted in its improvement.

B. *A Few Comments on the Problem of Stimulus Control*

A primary objection to certain research investigations of discrimination learning relating to the relational and absolute stimulus hypotheses is that the stimuli involved varied in more than a single dimension. Each stimulus actually provided opportunity for responding to two or more aspects or relationships in the situation. This lack of control is an inherent characteristic of a large number of complex stimuli. There is little doubt that stimuli which are distinctive from each other and which bear several differing relationships to their fields can be responded to in absolute terms.

To refer specifically to the matter of visual size as a stimulus: Several problems are presented if one attempts to vary the size of even a simple white circle on a black card of constant size. For example, if its size is to be doubled, does this mean that the stimulus (white) area is to be doubled? If the area is so increased, then is the size of the stimulus really doubled? The horizontal diameter has not been doubled, nor has the vertical diameter. If the horizontal diameter is doubled, even without doubling the vertical, then the stimulus is no longer a circle but an ellipse. If both diameters are doubled, then, of course, the stimulus is much more than doubled in total area.

Let us consider the matter more generally with an illustration: Frequently when size is utilized as the stimulus "dimension" to be discriminated, in the selection of the second stimulus more than one aspect of the stimulus situation is simultaneously changed, i.e., (*a*) the total *area* of the stimulus is modified, (*b*) the total quantity of illumination is altered, (*c*) the distance between the floor and base of the stimulus object or between the top of the stimulus object and the ceiling is (or both are) changed, (*d*) the distances between the stimulus-object and the peripheries of the field are altered, (*e*) there is a change in the size of the stimulus object (increase or decrease) relative to the size of the visual field. The animal may be responding to one or more of these variations or relationships. *Something of a patterned character exists in each stimulus.*

C. *Purpose of this Investigation*

The purpose of this investigation was to obtain evidence pertaining to the adequacy of relational and absolute stimulus-training techniques for discrimination learning by employing a method which involved a greater degree of stimulus control than has usually been achieved in research on discrimination. At the same time, relative effectiveness of learning under these two sets of conditions would provide evidence relevant to the theoretical positions on discrimination learning proposed by Köhler and by Spence.

II. The Design of the Investigation

A. *The Stimuli*

For the proposed investigation it was necessary to select simple stimuli which varied only in degree from other stimuli of the same class. To put the matter another way, the two stimuli to be employed were each to be as elementary as possible and the difference between the positive and the negative stimulus was to be confined to variation in degree of a single, not a multiplicity, of aspects. Such stimuli when presented singly, that is to say, in isolation, would then be simple and patternless, i.e., there would be no relationships apparent within a single stimulus. When presented to-

gether, however, these two stimuli would form a pattern, for according to gestalt psychologists, not only are the properties of each individual stimulus present, but also an additional quality or property dependent upon relational or comparative aspects of the two simultaneously present stimuli, in terms of which the animals may learn.

Stimuli which vary in brightness only are relatively simple, relatively convenient to employ, and are relatively easily controlled. Since such stimuli when employed singly, in isolation, fulfilled the requirements of the associationistic-type theory which proposes that discriminative learning is a function of the absolute properties of each stimulus, and since two such stimuli in combination fulfill the criterion of *patterned*, i.e., relational, stimuli for the gestalt-type theory, these have been utilized as the stimuli in this investigation.

B. *The Subjects*

1. *Number and ancestry.* The subjects (Ss) were 42 mature female albino rats obtained from the laboratory of Dr. E. L. Walker, at the University of Michigan. Group I consisted of eight animals, Group II of ten, Group III of 12, and Group IV of 12. Dr. Walker's rat colony originated with animals purchased from three commercial animal farms. Regarding the ancestry of the Ss, little is known except that attempts at selective breeding were confined to mating healthy animals, i.e., animals that gave no superficial signs of illness.

2. *Age and naïveté.* All Ss were naïve in the sense that none had been involved in any previous experimentation, psychological or otherwise. All animals were two to six months of age at the beginning of the experiment.

3. *General living conditions during the experiment.* The Ss were kept in a room separate from, but adjacent to, the experimental room.

After completing their trials for any day, animals were put into a neutral cage for 15 minutes and then transferred to a food cage where they were permitted to eat for about 30 minutes. The diet consisted of Purina Laboratory Animal Chow, supplemented weekly by green vegetables.

Animals in Groups I and II were employed successively, that is to say, work with Group II animals was not initiated until work with Group I animals was almost completed. The members of these two groups, while matched for weight, sex, age, and equivalence of background experience, were not, of course, from the same litters.

Animals in Groups III and IV were utilized at the same time, i.e., run on the same days, and these groups consisted of matched members of split litters. These animals were matched for weight, sex, age, and equivalence of background experience.

C. *Design of the Apparatus*

The apparatus was designed to permit variation in one stimulus aspect, viz., brightness, while maintaining others invariable and constant (11). The instrument employed was a modified Yerkes-type brightness discrimination apparatus.[4] It can be best described with the aid of Fig. 1, a floor plan diagram.[5]

1. *The discrimination box.* A tunnel, A, led to the discrimination box proper, B. A low partition one inch high, E, functioned to impede

[4] A more complete description of the apparatus and procedure (including additional diagrams), together with data on the performance of individual subjects, has been deposited with the American Documentation Institute. Order Document No. 4758 from ADI Auxiliary Publications Project, Photoduplication Service, Library of Congress, Washington 25, D.C., remitting in advance $2.00 for microfilm or $3.75 for photocopies. Make checks payable to Chief, Photoduplication Service, Library of Congress.

[5] Capital letters used from this point through the section to indicate parts of the apparatus refer to Fig. 1, Floor-Plan Diagram of the Apparatus.

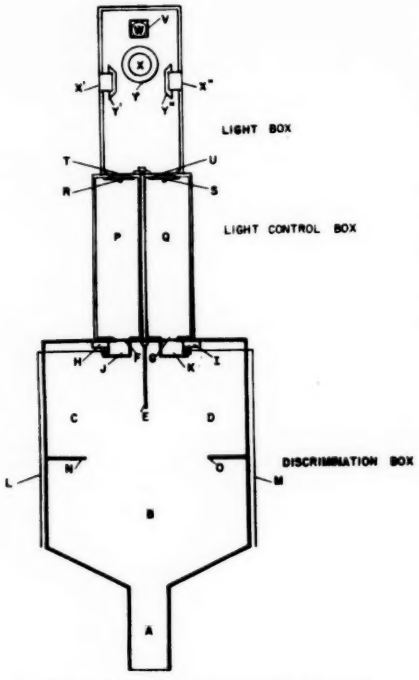

FIG. 1. Floor-plan diagram of brightness discrimination apparatus.

the attempts of the animal to move from one stimulus compartment to the other, C and D, but permitted the animal readily to observe the stimulus in the adjacent compartment. Stimulus windows, F and G, were square and of flashed opal glass. At the lateral aspect of each stimulus window was a food release mechanism, H and I, which deposited a single pellet at a time into a food trough, J and K, directly beneath the stimulus window when operated mechanically via two metal rods, L and M, by the investigator from a position near the tunnel. Two narrow vertical strips of metal, one on each side of each stimulus window, provided narrow grooves into which a thin metal plate, the stimulus window obstruction plate, could be fitted tightly so as to obscure completely the stimulus window and prevent any light from passing through it into the stimulus compartment. (These and many other details of the apparatus are diagrammatically represented in Fig. 2.)

2. *The light-control box.* The light-control box was located directly behind the discrimination box. This box enclosed two chambers, P and Q, separated from each other by a light-tight partition; the interior of each of these chambers was painted black. In the posterior wall of each chamber was a pair of shutter plates, R and S. The shutters were made of metal and painted black. A brass rod 1/8 of an inch in diameter passed vertically through the two metal blocks, one attached to the lower and the other to the upper shutter of each system and projected outside the light box. Each brass rod was so threaded that by appropriately turning it, the plates of the shutter system could be made to separate from or approach each other. This rod was called the light-regulation screw. Thin and separate sheets of uniformly bilaterally sanded glass, T and U, rested against each pair of shutter plates.

3. *The light box.* The most posterior structure was the light box. This was lined with sheet aluminum and contained a single 500-watt projection lamp, W, located on a small metal base, V. A ventilation system for the light box consisted of circular orifices in the floor, ceiling, and wall, X, X′ and X″, which were baffled by blackened sheets of metal, Y, Y′ and Y″. This arrangement permitted heat to escape but prevented light from doing so, and permitted the maintenance of a closed lighting system.

4. *The voltage stabilizer.* A voltage stabilizer was employed to guard against momentary voltage fluctuations and to maintain the voltage at 120 volts at the light box.

5. *Surface of the apparatus.* Except for a small part of the choice chamber, which was painted a medium gray, and the interior of the light box which was lined with aluminum, all of the apparatus, both inside and out, was painted flat black.

6. *Table.* The apparatus rested upon and was fastened by means of screws to a blackened heavy wooden table.

7. *The canopy.* The apparatus and table were enclosed within a canopy consisting of a wooden framework completely covered by black cloth.

8. *The lighting system.* The source of illumination for both stimulus windows was a single 500-watt lamp in the light box. Light emanating from this source passed through a sheet of uniformly sanded glass, through the diaphragm of the light-control box, then diffused through the two foot-long blackened corridors of the light box, and illuminated each flashed opal stimulus window with a high degree of homogeneity. A beveled type of window environment was used to ensure uniform illumination of each window and to obviate the possibility of shadow at the borders of the stimulus windows (see Detail A, Window Detail, of Fig. 2). Without this precaution, depth of shadow at the periphery of the window would vary with

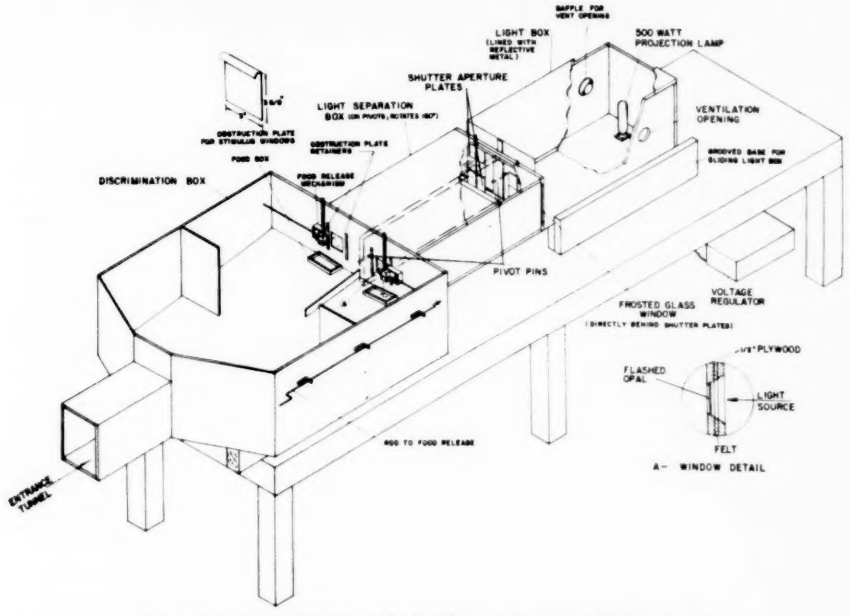

FIG. 2. Isometric diagram of the brightness discrimination apparatus.

the intensity of illumination. Contrast effects between shadow and general illumination of the stimulus might also occur. These could serve as unintended cues to the *Ss*. Furthermore, these uncontrolled variables might provide a possibility for learning to respond to individual stimuli by relational rather than absolute means.

9. *Measuring the brightness of the stimulus windows.* By means of a Weston Photoronic Cell and a microammeter and allied apparatus, the physical brightness of the stimulus windows for various turns of the light-regulation screw were determined in terms of foot-lamberts. From zero to 18 revolutions of the light-regulation screw an approximately rectilinear representation was obtained. In this paper it will be more convenient to indicate brightness by specifying the number of revolutions of the light-regulation screw which are integers than by specifying the brightness in terms of foot-lamberts, which demands the use of small fractions of units.

D. *Motivation*

Reinforcement was provided by food pellets, disclike tablets, composed of Purina Laboratory Animal Chow, each of which was slightly smaller than a standard size aspirin and each of which weighed approximately one centigram. Animals were run daily with an interval of 22 to 26 hours elapsing between each day's complement of ten trials.

E. *Procedure*

1. *Pre-experimentation handling.* The groups of animals were obtained about a month prior to the beginning of training of each group and had not been handled up to that time. With constant daily handling, defecatory, micturitional, and other diffusive behaviors progressively diminished.

2. *Preliminary training.* Groups I and II received no preliminary training. In an effort to reduce the time and trials required for reaching the criterion of learning, Groups III and IV were given four days of preliminary training. This preliminary procedure involved the following:

a. First day. Stimulus windows were not illuminated. The only sources of illumination were two 8-watt bulbs which were located on the top of the light-control box, and the rays of these were directed at the ceiling. No food was present in the discrimination apparatus and each group was permitted to explore the apparatus, a group at a time, for a half hour.

b. Second day. Stimulus windows were not illuminated. The only sources of illumination were the two 8-watt bulbs which were located on the top of the light-control box. Essentially this was a repetition of the procedure of the first day, except that the animals were placed in the apparatus individually and allowed to explore it for 15 minutes each.

c. Third day. Both stimulus windows were set with the positive stimulus, the dimmer. No other illumination was provided except that of the stimulus windows. Food pellets were placed in each food trough in a small pile. Animals were permitted to eat on either side. If they had not done so after 10 minutes had elapsed, they were guided to the side on which they had not yet eaten and were permitted to eat there. Each animal ate at least a few pellets on each side.

d. Fourth day. Both stimulus windows were set with the positive stimulus. No food was in the food troughs. Animals were put in at the tunnel and were given ten runs to the stimulus windows. The first five runs were unguided. But as many of the last five runs were guided as necessary to achieve a symmetry of five runs to the right and five runs to the left stimulus compartment. A single pellet was released after each run and the animal was permitted to eat it.

3. *The training of Group I.* The stimuli to be discriminated were the stimulus windows of flashed opal illuminated by an arbitrary setting of the light regulation screw, at one and seven complete revolutions. In terms of the physical measures used, these two stimuli possessed a brightness *ratio* also in terms of foot-lamberts of one to seven. The stimulus windows provided the only source of illumination for the animals in the situation. No other light source was permitted, and since the background was dark due to the unlighted room, the shrouding canopy, and the black surface of the apparatus, little light was reflected.

a. General procedure. For this group, the positive stimulus was the brighter; a relational technique was used, i.e., a technique in which the possibility existed of comparing or relating the stimuli since both were simultaneously present. On a given trial the rat was placed backwards, i.e., facing away from the stimulus windows in the entrance tunnel. Running time was recorded from the time all four feet of the rat emerged into the choice chamber of the discrimination box until the head and forefeet passed toward the stimulus window beyond the free end of the partition separating the stimulus compartments. A run this far was considered a choice or a decision and the animal was not permitted to retrace his run, or to cross the partition, or otherwise to emerge from the stimulus compartment until he was manually removed for the next trial.

If the animal's choice was to the positive stimulus compartment, a food pellet dropped from the food-release mechanism into the food trough directly in front of the stimulus window. A rod from the food release extended to the outside of the discrimination box and connected to another rod which ran laterally toward the "front" part of the discrimination box (behind the rat) where the experimenter stood (see Fig. 2). A slight movement of the experimenter's finger was sufficient to release mechanically a single pellet into the food trough. This device functioned in a highly efficient manner and there was little latency in the system. The animal was required to remain in the stimulus compartment, facing the stimulus window, for 10 seconds. If the animal's choice was to the negative stimulus compartment, the animal received no food. However, the animal was required to remain in the compartment for 10 seconds.

About 15 to 25 seconds elapsed be-

tween the completion of one run and the beginning of the next. Decision time and correctness or incorrectness of response were recorded during this period. Ten trials with the stimuli varying in a randomized fashion from trial to trial constituted the daily training. Animals were run until they reached the criterion of training, and for a varying number of days thereafter.

b. The criterion of learning. The criterion of training for this experiment was perfect performance on four successive days. In other words, in order to reach the criterion the animal was required to perform at a 100 per cent level of success, making no errors for four successive days with 10 trials per day. This was regarded as an adequate and rigorous criterion.

(i) Evaluation of the learning criterion according to the probability theory. In terms of probability concepts, the chance of this level of success occurring is extremely remote, 1 chance in 2^{40}.

(ii) Evaluation of the learning criterion according to currently employed standards. In terms of meeting the standards set to date by comparative psychologists, this criterion appears to be adequate. Munn, in discussing learning criteria of discrimination experiments (15), makes this summary type statement: "When the animal discriminates between the two stimuli with an accuracy of anywhere from 80 per cent to 100 per cent for from 30 to 50 successive trials, the problem is usually regarded as learned." The criterion, as indicated above, falls within the ranges specified by Munn.

(iii) Evaluation of the criterion by empirical test. An empirical test of the criterion was likewise attempted. Animals who had reached the criterion were run for additional days in order to obtain evidence relevant to the adequacy of the criterion, i.e., in order to be more certain that the performance of the animals was a relatively stable modification of behavior.

4. *The training of Group II.* In training, the same stimuli were used for Group II as for Group I, and again the positive stimulus was the brighter. Training, however, was by the absolute technique which did not permit a simultaneous comparison of the aspects of the component stimuli. Only a single stimulus, either the positive or negative, was exposed at a time. Since the animal could view but one stimulus at a time, there was no opportunity for direct comparison of the stimuli used. The stimulus exposed was sometimes on the left and sometimes on the right, the order being randomized. Exposing but a single stimulus was accomplished by sliding a black obstruction plate, the stimulus window obstruction plate, in front of one stimulus window. This served to obscure completely that window and to create a homogeneous black field in that stimulus compartment. On each day's complement of trials, the negative stimulus was exposed three times, the positive stimulus seven times. If the animal ran to the stimulus compartment in which the negative stimulus was exposed, the animal received no reinforcement. It was delayed in the compartment for about 10 seconds. It was then put on a waiting platform for about 15 to 25 seconds, during which time the stimulus windows were appropriately altered for the next trial. If the animal responded positively, it was reinforced with a single food pellet which dropped into the trough directly in front of the stimulus window. Runs to the nonstimulus compartment were, of course, nonreinforced, although they were recorded.

The same standards and procedures in terms of length of time permitted in the

tunnel, length of time permitted in the choice chamber, etc., applied to Group II as applied to Group I.

The animals in Group II were given 10 trials daily as indicated above. In terms of total trials, each animal was run until it had received at least as many reinforcements with the positive stimulus and as many reinforcements with the negative stimulus as were required for the poorest, i.e., slowest animal in Group I to reach the criterion of learning. In actual practice each animal made 600 runs. According to the Spence concept of discrimination learning, such training with the individual stimuli would provide for the development of strong positive reactions (approach tendencies) to the reinforced stimulus and of strong inhibition of approach reactions with regard to the nonreinforced stimulus. This theory would hold that discrimination is essentially a matter of building up specific habits of response to each component of the paired stimulus situation. Hence, ability of the animals in this group to make discriminations appropriately in the *test* trials subsequent to training would tend to support the associationistic or absolute stimulus hypothesis; failure to do so, however, would lend support to the gestalt-type or relational stimulus hypothesis.

5. *The training of Group III.* Twelve albino female rats constituted this group. The stimuli to be discriminated for Groups III and IV were the same as the stimuli provided for Groups I and II, i.e., stimulus windows of flashed opal were illuminated by arbitrary settings of the light regulation screw at one and seven complete revolutions.

For Group III the positive stimulus was the dimmer; a relational training technique was employed. Except for the fact that these animals received four days of preliminary training, and were trained to the dimmer rather than to the brighter stimulus, they were handled and treated exactly like the animals in Group I. The same criterion of learning, length of time permitted in the tunnel, length of time permitted in the choice chamber, etc., applied to group III as to Group I.

6. *The training of Group IV.* Twelve female albino rats constituted this group. For Group IV the positive stimulus was the dimmer; an absolute training technique was used (previously described when Group II training was considered). Except for the fact that these animals received four days of preliminary training, they were handled and treated in exactly the same way as the animals in Group II.

The animals in Group IV were given ten trials daily as indicated above. Each animal was run until it had received at least as many reinforcements with the positive stimulus and as many nonreinforcements with the negative stimulus as were required for the poorest (i.e., slowest) *S* in Group III to reach the criterion of learning. In actual fact, each animal made 600 runs. According to the Spence concept of discrimination learning, such training with the individual stimulus would provide for the development of strong positive reactions (approach tendencies) to the reinforced stimulus and for the development of strong inhibition of approach reactions with regard to the nonreinforced stimulus. It would hold that discrimination is essentially a matter of building up specific habits of response to each component of the paired stimulus situation. Hence, ability of the animals in this group to make such discriminations appropriately in the *test* trials subsequent to training would tend to support the

Spence or absolute stimulus hypothesis; failure to do so, however, would tend to support the gestalt-type or relational stimulus hypothesis.

F. *Special Precautionary Techniques Instituted for this Research*

In order to minimize the possibility of unintentional and extraneous stimuli serving as guidance cues to the animals, the following precautionary techniques were instituted:

1. *Attire of experimenter: minimizing visual cues from the experimenter.* During each trial the experimenter (*E*) stood motionless at one particular place, behind the discrimination box (i.e., opposite to the wall in which the discriminable stimuli were situated). The *E* wore a full-length laboratory coat which was dyed black, a black mask over his face which contained small slits at eye level to permit vision, and tight-fitting skullcap. The purpose of this attire was to minimize the possibility of *E* communicating cues, however unintentional, to the *S*s. It was believed that little if any light was reflected from *E* under these conditions and, therefore, movements, even unintentional guide cues, were unlikely to be communicated to the animals.

2. *Disorientation of animals at the beginning of each trial: minimizing handling cues from E.* At the beginning of each trial the animal was placed backwards (i.e., with its head toward the entrance) in the tunnel. This provided for a temporary disorientation in space which facilitated the dissipation of any tactual-kinesthetic cues that might have been given inadvertently in handling the animals; it is *E*'s belief that there was almost no variation in the handling of the animals from trial to trial.

3. *Homogeneity of the environment: reduction of cues from the apparatus and surroundings.* The apparatus rested upon and was fastened by means of screws to a wooden table previously indicated. The apparatus and table were enclosed within an artificial darkroom, a canopy of black. This was constructed of a wooden framework painted black. Fastened to the framework by thumb tacks on all sides including the ceiling (but not the floor) was black cloth.

The experimental room in which the canopy and other equipment were placed was completely darkened. Since the only source of light in this situation was that of the stimulus windows, it is believed that there was no opportunity for responding to other stimuli than these, at least other visual cues.

4. *Randomization in the presentation of the stimuli.* In order to minimize the possibility of a position habit being rewarded more than a chance number of times, a random order of presentation of the stimuli was utilized. The following 16 different relatively random series of stimulus presentations were employed on successive days. These were as follows: LRRLRRLRLL, RLRLLRRRLL, LLRRLRLLRR, RLLLRRLRLR, LRLLRRLRRL, LRLRLLRRLR, RLLRRLRRLL, RRLRLLLRLR, LRLRRLLLRR, RRLLRLRRLL, RLLRLLRLRR, LRRRLLRLRL, RLRLRRLLRL, LRRLLRLLRR, RLRRLLRLLR, LLRLRRRLRL.

In the case of Groups I and III the R or L indicated the position of the positive stimulus. Groups II and IV, however, were given absolute stimuli, i.e., were trained with only a single stimulus exposed, sometimes the positive and sometimes the negative. The same series was used for Groups II and IV, but, of every 10 stimuli exposed in each day's complement, the positive was exposed several times, the negative three times for Groups II and IV. The sequences were as follows: A minus (—) sign follows the designation of position to indicate that the exposed stimulus was negative; all others are positive. LR — RLR — RL — RLL, RLRL — L — R — RRLL, LLR — R — LRL — LRR, RL — LLR — RLRL — R, L — RL — LRRLRR — L, L — RLRLLRR — LR —, RL — LRR — LRRLL—, RRLR — LL — LR — LR, LRL — R — RLL — LRR, RR — L — LRLRR — LL, RLLRL — L —RLRR —, LRR — RLLR — LRL—, RL — RL — RR — LLRL, LRR — LL — RLLRR —, RLR — RLL —RLL — R, LLRLRRR — LR — L—.

5. *Reduction of food cues.* Food appeared to be comparatively odorless. There were an approximately equal number of food pellets in the tubes of the food-release mechanisms of either stimulus compartment at all times. Furthermore, a differential quantity of food on either side, even if detectable olfactorily, would provide no differential cue regarding the correct stimulus window since food was unavailable to the animal until the experimenter released it, and food was not released until *after* a correct choice had been made.

III. The Results of the Investigation

A. *The Primary Results of the Investigation*

The main results of this investigation are contained in Tables 1, 2, 3, 4, 5, and 6; certain closely related supple-

mentary data which summarize the accuracy of postcriterion trials are contained in Tables 7 and 8.

The primary results are indicated below:

1. *Group I results.* The *Ss* in Group I learned to respond positively to the brighter of two stimulus windows under conditions of relational stimulus training. *All ($N = 8$) subjects attained the criterion of learning,* which consisted of perfect runs of four successive days of 10 trials per day (40 consecutive errorless responses) in from 210 to 390 trials. The mean number of trials (both reinforced and nonreinforced) required for reaching the criterion was 316.3 (see Table 1).

The slowest learner in Group I, in terms of the number of reinforced responses to the positive stimulus prior to learning, required 279 reinforced trials; the slowest learner in Group I, in terms of the number of nonreinforced responses to the negative stimulus prior to learning required 132 nonreinforced trials.

2. *Group II results.* The *Ss* in Group II were trained under conditions that did not permit relational learning, i.e., by the absolute stimulus method that did not permit comparison between the stimuli, and each of these was given more positive (reinforced) and negative (nonreinforced) trials than the slowest learner in Group I. Hence, in comparison with Group I results, each animal in Group II received 346 or more reinforced trials to the positive stimulus; each animal in Group II received 144 or more nonreinforced trials to the negative stimulus (see and compare Tables 1 and 2).

TABLE 1

LEARNING DATA FOR GROUP I SUBJECTS WHO WERE TRAINED BY THE RELATIONAL METHOD WITH THE BRIGHTER STIMULUS AS POSITIVE

	Trials Required for Learning	No. of Responses to Positive Stimulus (Reinforced Trials)	No. of Responses to Negative Stimulus (Nonreinforced Trials)
Range	210–390	149–279	61–132
Mean	316.3	205.6	110.6
SD	59.8	43.4	21.9

TABLE 2

LEARNING DATA FOR GROUP II SUBJECTS WHO WERE TRAINED BY THE ABSOLUTE METHOD WITH THE BRIGHTER STIMULUS AS POSITIVE

	No. of Responses to Positive Stimulus (Reinforced Trials)	No. of Responses to Negative Stimulus (Nonreinforced Trials)	No. of Responses to Nonstimulus Compartment
Range	346–408	144–176	18–110
Mean	377.2	161.5	61.3
SD	18.6	9.4	27.7

Most of the *Ss* in Group II ($N = 10$) reached or closely approximated the criterion of learning (see Table 3). Three animals in this group, however, made 4, 11, and 13 errors on their respective test trials (see Table 3).

3. *Group III results.* The *Ss* in Group III learned to respond positively to the dimmer of two stimulus windows under conditions of relational stimulus training. All ($N = 12$) *Ss* reached the criterion of learning which consisted of perfect runs on four successive days of 10 trials per day in from 240 to 430 trials. The mean number of trials required for learning was (both reinforced and nonreinforced) 309.2 (See Table 4).

The slowest learner in Group III, in terms of the number of reinforced responses to the positive stimulus prior to learning, required 269 reinforced trials; the slowest learner in Group III, in terms of the number of nonreinforced re-

TABLE 3

ERRORS OF GROUP II SUBJECTS ON TEST TRIALS WITH BRIGHTER STIMULUS AS POSITIVE

	Test Trials				Total No. of Errors	Per Cent of Success
	1st Day (Trials 1–10)	2nd Day (Trials 11–20)	3rd Day (Trials 21–30)	4th Day (Trials 31–40)		
Total	6	10	8	6	30	
Range	0–5	0–5	0–4	0–3	0–13	67.5–100
Mean	0.6	1.0	0.8	0.6	3.0	96.3

sponses to the negative stimulus prior to learning, required 161 nonreinforced trials.

4. *Group IV results.* The *S*s in Group IV were trained under conditions that did not permit relational learning, i.e., by the absolute method, which did not permit comparison between the stimuli, and each was given more positive (reinforced) trials and more negative (nonreinforced) trials than the slowest learner in Group III. Hence, in comparison with Group III results, each animal in Group IV received 327 or more reinforced trials to the positive stimulus; each animal in Group IV received 163 or more nonreinforced trials to the negative stimulus, except one subject of this group who through an oversight received only 159 nonreinforced trials (see Tables 4 and 5).

The subjects in Group IV (N = 12) did not even remotely approximate the learning criterion (see Table 6). With the exception of one animal that obtained a score of 50 per cent success on the test trials by adopting a position habit, no *S* exhibited more than 45 per cent success on the test trials. And one animal was successful only 2.5 per cent of the time, which represents one correct run of the 40 test trials. Hence, the Group IV animals, like the animals in Group II on being tested, displayed from slight to very strong preferences for the brighter stimulus, although these animals had received absolute training to the dimmer, and had been reinforced during the training only with the dimmer stimulus.

One *S* of this group displayed a position habit from the very first test trial. Preferences for the negative, i.e., the brighter, stimulus existed in all other *S*s of this group on the initial trials, after which rigid stereotyped position re-

TABLE 4

LEARNING DATA FOR GROUP III SUBJECTS WHO WERE TRAINED BY THE RELATIONAL METHOD WITH THE DIMMER STIMULUS AS POSITIVE

	Trials Required for Learning	No. of Responses to Positive Stimulus (Reinforced Trials)	No. of Responses to Negative Stimulus (Nonreinforced Trials)
Range	240–430	140–269	87–161
Mean	309.2	191.5	117.7
SD	47.0	45.5	18.8

TABLE 5

LEARNING DATA FOR GROUP IV SUBJECTS WHO WERE TRAINED BY THE ABSOLUTE METHOD WITH THE DIMMER STIMULUS AS POSITIVE

	No. of Responses to Positive Stimulus (Reinforced Trials)	No. of Responses to Negative Stimulus (Nonreinforced Trials)	No. of Responses to Nonstimulus Compartment
Range	372–402	159–172	30–114
Mean	378.8	166.7	54.6
SD	22.3	3.5	25.1

TABLE 6

ERRORS OF GROUP IV SUBJECTS ON TEST TRIALS WITH DIMMER STIMULUS AS POSITIVE

	Test Trials				Total No. of Errors	Per Cent of Success
	1st Day (Trials 1–10)	2nd Day (Trials 11–20)	3rd Day (Trials 21–30)	4th Day (Trials 31–40)		
Total	91	77	74	72	314	
Range	5–10	5–9	5–10	4–10	20–39	2.5–50
Mean	7.6	6.4	6.2	6.0	26.2	32.5

sponses were exhibited by several of them.

5. *Empirical test of the learning criterion.* In order to evaluate the adequacy of the criterion of learning employed in this investigation, *Ss* in Groups I and III were given a varying number of trials (from 10 to 200) subsequent to their achievement of the criterion. Of the *Ss* in Group I, none performed with an accuracy level of less than 92.3 per cent during this postcriterion evaluation period (see Table 7); of the *Ss* in Group III, none performed with an accuracy level of less than 90 per cent during this postcriterion evaluation period (see Table 8). These data seem to indicate that the modified behavior is relatively stable and not a transient phenomenon, and as such fulfills an essential requisite of most definitions of learning.

6. *Transposition data.*

a. Transposition training results. Animals in Groups I and III subsequent to their postcriterion trials were trained by the relational method for a period of 15 days, 150 trials, to discriminate between stimulus windows set at 2 and 6 revolutions of the light-regulation screw. For Group I, the brighter, 6, was the positive and, hence, reinforced stimulus. For Group III, the dimmer, 2, was the positive, and hence, reinforced stimulus.

On the first 10 trials of these 150 training trials mentioned above, the stimulus windows were set at 1 and 6 revolutions of the light regulation screws. In Group I, *Ss* continued to discriminate with better than 95 per cent accuracy on these 10 trials. From the 11th trial on, the windows were set at 2 and 6. Between the 11th and 20th trials the accuracy level of Group I dropped to 78.8 per cent, but a trend of improvement in the accuracy of response occurred with successive practice during the training period. The accuracy of Group III *Ss* fell to 90 per cent on the first 10 trials; it remained at about this level between the 11th and 20th trials, after which a trend of improvement in the accuracy of performance occurred with successive practice during the training period.

Animals then were tested in order to

TABLE 7

POSTCRITERION RUNS FOR GROUP I SUBJECTS

	Total No. of Responses	No. of Responses to Positive Stimulus	Per Cent of Accuracy
Range	10–180	10–178	92.5 to 100.0
Mean	82.5	79.3	96.1

TABLE 8

POSTCRITERION RUNS FOR GROUP III SUBJECTS

	Total No. of Responses	No. of Responses to Positive Stimulus	Per Cent of Accuracy
Range	10–200	10–183	90.0–100
Mean	130.8	124.3	95.0

determine the extent of transposition by transposition stimuli, the component stimuli of each pair of which bore the same brightness relations to each other as the component stimuli of the standard pair of Stimuli 2 and 6. Hence, animals were tested with one pair of stimuli set at ⅔ and 2 revolutions and another pair set at 6 and 18 revolutions.

b. Transposition test results. The transposition test consisted of 50 trials. Of the 50 trials during the transposition test days, 30 were to the standard stimuli of 2 and 6 upon which the animals were trained. Responses to this pair were reinforced if correct (i.e., if the responses were to the positive stimulus). The purpose of these presentations of the standard pair was to keep the animals trained to the brighter (Group I) or to the dimmer (Group III) stimulus of the pair. Interposed among these standard stimulus presentations were 10 presentations of the stimuli set at ⅔ of a revolution and 2 revolutions, and 10 presentations of the stimuli set at 6 and 18 revolutions. No reinforcements occurred on these test trials regardless of whether the responses were to the positive or negative stimuli.

For each group this meant that on certain trials the originally negative stimulus (negative stimulus of the standard pair) was presented with a new stimulus, and on other trials the originally positive stimulus (positive stimulus of the standard pair) was also presented with a new stimulus. If the animal had been trained to the absolute properties of the stimulus, it should then respond appropriately to the original stimuli by "avoidance" or approach. However, if the *S*s had learned to respond to a relational characteristic (i.e., a comparative aspect) of a pair of stimuli, the *S*s should respond in the opposite way.

Results of the transposition tests are summarized in Tables 9 and 10. It is to be noted that the proportion of errors was approximately the same with the presentations of the new (transposition) pairs of stimuli as it was with the presentations of the training (standard) pairs of stimuli in the test. For both groups the mean success was above 85 per cent (see Tables 9 and 10). These results are interpreted to mean that the animals were responding to a relationship between the stimuli rather than the absolute properties of the individual stimuli.

B. *The Secondary Findings of the Investigation*

Following is a summary of some of the secondary findings of this investigation:

1. *The latency data: reaction times.* Reaction (i.e., decision or choice) time

TABLE 9

ERRORS ON TRANSPOSITION TESTS FOR GROUP I SUBJECTS WHO WERE TRAINED TO RESPOND TO THE BRIGHTER STIMULUS

	Transposition Stimuli		Total No. of Errors (20 trials per subject)	Reactions to Standard Pair
	No. of Revolutions of the Light-Regulation Screw			
	2/3 and 2 (10 trials per subject)	6 and 18 (10 trials per subject)		2 and 6 (30 trials per subject)
Total	6	10	16	27
Range	0–2	0–3	0–4	0–6
Per Cent Accuracy	92.5	87.5	90	88.8

TABLE 10

ERRORS ON TRANSPOSITION TESTS FOR GROUP III SUBJECTS WHO WERE TRAINED TO RESPOND TO THE DIMMER STIMULUS

	Transposition Stimuli		Total No. of Errors (20 trials per subject)	Reactions to Standard Pair
	No. of Revolutions of the Light-Regulation Screw			
	2/3 and 2 (10 trials per subject)	6 and 18 (10 trials per subject)		2 and 6 (30 trials per subject)
Total	12	24	36	44
Range	0–3	1–3	1–6	0–10
Per Cent Accuracy	90	80	85	87.8

data are of incidental importance in this investigation. At first most *Ss* in all groups made decisions slowly. When the animal hesitated in the choice chamber for more than 30 seconds, it was prodded toward the center and toward the stimulus windows. Such hesitations were most frequent in the early trials. Speed of decision began to increase (i.e., choice time decreased) after varying numbers of trials. On later trials almost all runs were made in one second, arbitrarily the shortest time recorded, or less. A summary of the reaction-time scores for each group is contained in Table 11, which sets forth the data in support of the statements above.

2. *Error scores and learning curves.* The training period for each animal was divided into 10 equal units, each of which, therefore, constituted 10 per cent of the total training period. The number of errors occurring within each of these subperiods was then tabulated, and a distribution of the percentage of errors in each of these subperiods was prepared. The data, grouped in this way (i.e., in terms of Vincent tenths), have permitted plotting of individual learning curves for each animal in Groups I and III in terms of Vincent tenths. The percentage of incorrect responses for each tenth of the training period was indicated. The learning curves derived from results of this investigation are typical of those reported for discrimination learning; they indicate that for the first half to three-quarters of the learning period, error scores vary about (i.e., remain near) the 50 per cent level; then there is a relatively sharp—at least a sharper—downward progression of the curve, indicating a rather sudden increase in accuracy of performance. That is, to say after a long period of no apparent progress, with the results near the chance level, there is a relatively sudden increase in accuracy.

IV. DISCUSSION OF THE RESULTS OF THE INVESTIGATION

A. *Discussion of the Principal Results*

The results of this research tend to support the gestalt hypothesis of discrimination, namely, that discrimination is dependent upon some comparative or relational aspect between the stimulus constituents of a pattern. The results seem to indicate that training with relational stimuli, i.e., with both stimuli of a pair simultaneously present, is not equivalent or reducible to absolute training, i.e., individual training, with only one component stimulus of the pair present at a time. The differences are more

TABLE 11

LATENCY DATA: TABLE OF PERCENTAGES OF REACTION TIME SCORES DURING STAGES OF DISCRIMINATION TRAINING FOR ALL GROUPS

Group No.	Reaction Time Categories (in minutes)	Early Stage (First 30% of Trials)	Intermediate Stage (Middle 40% of Trials)	Late Stage (Last 30% of Trials)
I ($N=7$)*	31 and over	2.6	0.6	0.0
	6 to 30	15.1	2.3	0.1
	2 to 5	37.6	4.7	0.7
	1	44.7	92.3	99.1
	Total	100.0	99.9	99.9
II ($N=10$)	31 and over	13.4	0.0	0.0
	6 to 30	22.6	2.1	0.2
	2 to 5	32.7	8.0	1.4
	1	31.3	89.9	98.4
	Total	100.0	100.0	100.0
III ($N=12$)	31 and over	5.1	0.0	0.0
	6 to 30	15.2	2.2	1.9
	2 to 5	18.9	5.9	6.1
	1	60.8	91.8	92.0
	Total	100.0	99.9	100.0
IV ($N=12$)	31 and over	7.0	0.0	0.0
	6 to 30	17.0	1.4	0.3
	2 to 5	25.0	4.9	2.5
	1	51.0	93.7	97.1
	Total	100.0	100.0	99.9

* The data for Group I summarized in this table include only seven of the eight *Ss*. The latency data for one *S* were excluded because they were so radically different from those of all other *Ss* that they would have obscured the general trends of the other members of the group.

clearly apparent when Groups III and IV are contrasted than when Groups I and II are contrasted. To some extent this may be due to certain improvements in techniques with Groups III and IV, but the greater likelihood is that the differences in clarity of the results are due to certain other factors to be discussed later in this section. Among the improvements in technique involving Groups III and IV are the following:

1. In the first place, Groups III and IV were composed of split litters, animals of each group of which were matched for weight, age, sex, naïveté, and equivalence of environmental background. Groups I and II consisted of animals matched for age, sex, weight, naïveté, and synonymity of environmental background, but, of course, were not from the same litters, since Group II training did not begin until Group I training was at an end.

2. In the second place, Groups III and IV were given trials on the same days. This meant increased likelihood of equivalent handlings. Groups I and II, of course, were run several weeks apart on the corresponding trials.

3. In the third place, Groups III and IV received preliminary training. Groups I and II did not. Hence, it is difficult to know how much of the early part of the experiment for those animals (Groups I and II) was devoted to general exploration within the apparatus. One can be more certain that the animals in Groups III and IV who received preliminary

training were attentive to relevant stimulus cues in the early part of the training period.

4. In the fourth place, the sizes of the samples in Groups III and IV were larger than in I and II.

According to the Spence theory of discrimination learning, learning consists of the relatively simple process of developing differential strength among alternative stimulus-response connections, as determined by selective reinforcement and nonreinforcement. This concept emphasizes the frequency of stimulus-response-reinforcement sequences. Each occurrence of this sequence results, according to the theory, in building up cumulatively a certain amount of associative (habit) strength. Likewise, according to the theory, the stimulus-response-nonreinforcement sequence produces a cumulative building-up of inhibitory strength.

If this theory were valid, then each animal in Groups II and IV, respectively, since they received more reinforcements for responses to the positive stimuli and more nonreinforcements for responses to the negative stimuli than the poorest animals in Groups I and III, respectively (trained relationally to the same stimuli), should have developed, to a much greater extent than any animal in Group I or III, the appropriate habits involved in the solution to the discrimination problem. But such was not the case.

Despite the fact that Group II animals each received more positive (reinforced) trials and more negative (nonreinforced) trials to the appropriate stimuli than even the poorest animal in Group I, the behavior of some of the animals in Group II was not equal to the behavior of all of those in Group I. On being tested, five of the animals did attain the same criterion of "perfection" as the animals in Group I; two other animals, each of which made one error during the tests, practically reached the criterion. But one animal made errors on 10 per cent of the criterion runs, another made errors on 27.5 per cent of the criterion runs, and another made errors on 32.5 per cent of the criterion runs. This is clearly not equal to the "perfect" performance of every animal in Group I. However, because of the fact that, in the respects mentioned above, the procedure employed with Group I and II *Ss* was less adequate than that employed with Groups III and IV, our attention should be concentrated upon a comparison of the latter groups. The evidence in regard to these groups is sharp and distinct. It clearly favors the gestalt interpretation. Although each animal in Group IV, the absolute stimulus group, received as many positive (reinforced) and as many negative (nonreinforced) trials as the poorest animal in Group III, the relational stimulus group, *none of the animals in Group IV even remotely approached the criterion of learning which all of the animals in Group III met.* One animal (Group IV, No. 8) obtained a "chance" score of 50 per cent. The animal accomplished this score by adopting a position habit from the very first test trial. During the training in the days prior to the test, the animal had responded with equal alacrity to either stimulus component by approaching it, regardless of the compartment in which the stimulus was exposed. (It did not matter whether the stimulus presented was negative or positive.) No other animal on the discrimination tests for Group IV achieved a score of over 45 per cent. The mean success of these animals was 32.5 per cent; and one animal (Group IV, No. 2), on being tested, selected the dimmer stimulus, which was the positive, only once in the 40 test trials, making an ac-

curacy score of 2.5 per cent. Hence, it is apparent that the animals in Group IV, like the animals in Group II, displayed a strong preference for the brighter of the two lights. And this occurred despite the fact that the training was exactly the opposite in terms of the differential reinforcement and nonreinforcement of the same stimuli. Clearly the results are not those which the associationistic theorists would predict. The Spence theory would hold that, with such differential training, opposite specific habits for the two groups should have been developed, but obviously this was not the case.

B. *A Suggested Explanation for the Response Tendency to the Brighter Light in Both Absolute Groups*

In view of the fact that differences between Groups III and IV are obvious, the less obvious differences between Groups I and II demand explanation. Actually, of course, one cannot directly compare the first two groups with the last two groups because of at least one difference in procedure, viz., Groups III and IV received preliminary training whereas Groups I and II did not. However, the following is a suggested explanation:

For the absolute groups, as a consequence of partial reinforcement to light, a general light-going tendency, *but not a tendency to go to specific light*, was developed. The learning situation for these groups was one in which a single light was exposed, the other stimulus window being covered and apparently indistinguishable from the dark ground. The animals, therefore, learned to go to a spot of light. And this is what they continued to do when tested. Since two spots of light differing greatly in brightness were presented in the test, the rats reacted to the more prominent. Hence, the animals in both Groups II and IV, regardless of which stimulus they were trained to approach (the brighter or the dimmer), chose the brighter stimulus on being tested.

Hull, Spence, and other associationistic theorists would have predicted that animals with reinforcement for responses to a particular stimulus would develop the strength of the excitatory tendency (i.e., the positive tendency or tendency to evoke the approaching response) with regard to this stimulus; and with nonreinforcement for responses to another specific stimulus would develop the inhibitory tendency (i.e., the negative tendency) with regard to that stimulus. Hence, the animals in Group IV should have approached the dimmer stimulus and avoided the brighter stimulus as a consequence of their previous training. This was not the case. There was not even a trend to approach the positive stimulus. In fact, taken at face value, the evidence seems to indicate that the training had an adverse effect, for despite previous training toward the dimmer light, on exposure to both lights simultaneously, the animals in Group IV, like the animals in Group II, tended to approach the brighter.

C. *Discussion of Position Habits Developed and of Light Reactions During Tests of Absolute Groups*

In interpreting the results of tests involving the absolute groups, at least three facts must be considered.

1. The final testing situation involved the simultaneous presence of two stimuli, whereas prior to this time (i.e., during the training trials) the animals had been confronted by only a single stimulus at a time. It will be recalled that during the training period *S* approached each of the light stimuli at different times when individually presented. If during the final test *S* tended to react to both of the

simultaneously presented lights in the same manner as to these stimuli when individually presented, the situation would be one of confusion.

2. Tremendous differences existed in the intensity of the two lights; one light was physically several times as bright as the other. Hence, the animals might respond to only the most prominent (brightest) of the two, the other light being relatively "unnoticed."

3. As a consequence of differential reinforcement and nonreinforcement for the stimuli during the early trials of the final test situation (which permitted relational discrimination), modification of response tendencies on the *later* trials of the final test situation might have occurred.

In Group II tests, animals on initial trials tended to respond to the most prominent of the two lights and were always rewarded for such responses. Although the presence of two lights might have been confusing, the reinforcement for brightness responses tended to confirm this reaction tendency, i.e., the tendency to approach the brighter light. But even in this group two animals developed position habits. One *S* made all runs to the left on the first two test days, and on the third day made 8 of its 10 runs to the left; but on the fourth day it responded to the brighter light on each trial. The fourth day's responses might have been a consequence of the differential reinforcement and nonreinforcement of the first three days. Another *S* responded to the most prominent, i.e., the brighter light, on the first day's complement of test trials. However, on the second day, 9 of the 10 responses were again to the right; on the third day, 9 of 10 responses were again to the right, on the fourth day, 8 of 10 responses were to the right side. It is suggested that effective stimulation of the animal by two stimuli after the first day provided a situation of confusion responsible for the development of position habits.

In the case of Group IV, animals on initial trials responded to the most prominent of the two lights and were never rewarded for so doing. Thus, there was not reward, but a situation of disturbance, of constant frustration for those reactions. The presence of two lights, of course, might have produced an additional confusing factor. Under these conditions, behavior was modified, and position habits were established. Since the position habits were partially reinforced, whereas the previous responses to the brighter stimulus were not reinforced, they (the position habits) tended to persist. It is possible that these position habits, too, would have been resolved if sufficient practice were allowed in the relational situation; but this would have changed the situation from one of test to one of further training by a second method.

D. *Discussion of Transposition Test Results*

The results of transposition tests with Groups I and III, in which *S*s, after being trained to a standard pair of stimuli, were tested with the positive stimulus or the negative stimulus of an original (standard) pair and a new stimulus, still further positive or negative, indicate that the *relationships* between the stimuli and *not their absolute properties* are the basis for discrimination.

E. *Comment on the Difficulty of the Discrimination Problems*

In spite of the fact that a greater mean number of trials was required to learn the discrimination in which the brighter stimulus was positive as compared with

the same pair of stimuli with the dimmer positive (the mean for Group I was 316.3; the mean for Group III was 309.2) it is suggested that the discrimination with the dimmer as positive is a more difficult one to learn. While the direct comparison of the first two groups and the last two groups is restricted by the differences in procedure employed, it is doubtful that such procedural differences, such as preliminary training, influenced the results, except in the rate of learning. It is probable that the preliminary training of Group III (see preliminary training, under "Procedure" in Section II) served to familiarize the animals with the learning apparatus so that general exploratory behavior was less necessary when the training trials, per se, started. Hence, since some familiarity with the apparatus was accomplished prior to the formal training, diffuse, exploratory behavior in the apparatus was reduced, and the total trials required for learning were correspondingly reduced.

F. *Suggestions for the Design of a Future Experiment to Obtain Further Data on this Problem*

Even though the results of this investigation, particularly the comparisons involving Groups III and IV are fairly clear, at least three suggestions may be made which the investigator believes would contribute to the evidence and yield even more obvious results in the same direction.

1. First of all, differences in physical intensity between the two stimuli should be reduced and differential thresholds of brightness for the rat should be determined in a preliminary investigation. Settings of the stimuli for training and testing in the experiment would then depend on the results of this preliminary investigation.

In the current investigation, stimuli that were obviously different from each other were employed. One stimulus was approximately seven times as bright as the other (in terms of physical units). Moody, in one investigation of the deermouse, found that the minimum differential threshold between brightness stimuli was 1 to 1.6 (14). It is likely that the ratio for the white rat is somewhere in the vicinity of this ratio.

There is, of course, little doubt, that if stimuli differ tremendously from each other so that they set up secondary responses and sensations, probably they could be learned in absolute terms. Hence, the problem should involve stimuli which differ from each other minimally rather than maximally.

That these two stimuli (used in the present investigation) were readily distinguishable from each other is obvious, for Group IV animals did respond in the test with a decided preference for the bright light. Thus, although they did not learn the solution to the discrimination problem, they did distinguish between the stimuli. If the differences between the stimuli were greatly reduced so that they were less readily distinguishable, probably there would be no differential reaction except with relational training.

2. Second, Ss should receive a considerable amount of handling prior to the beginning of the experiment to ensure tameness, and should have had considerable familiarity with the apparatus. Animals sophisticated in this way are easier to deal with than the more naive. It also seems reasonable to assume that such animals will learn most rapidly, since they are not so apt to attend to exploration and irrelevant stimuli at the beginning.

3. Third, the space between the stimulus windows should be reduced. In the present investigation, the internal edges of the two stimulus windows were 5½ inches apart. If these stimulus windows were moved nearer together so that the internal stimulus borders of each were only one or two inches apart from each other, this condition might provide a better opportunity for contrasting and comparing of the two stimuli when presented simultaneously; this condition, of course, according to advocates of associationistic theories, should have no particular effect upon the absolute stimuli individually presented.

G. *Interpretation of Essential Findings*

Absolute training in which no opportunity for direct and simultaneous comparison of the component stimuli exists is not equivalent in efficacy to relational training in which there is an opportunity for direct and simultaneous comparison of the component stimuli. When the

term *comparison* is used here, we are not speaking of a higher mental process or a judgmental process, but merely implying that the organism can respond on the basis of an objective relationship.

The discriminatory response is not strictly a cumulative function of building up specific positive habits to specific stimuli as a consequence of a stimulus-response-reinforcement sequence, and a cumulative function of building up of inhibition as a consequence of a stimulus-response-nonreinforcement sequence.

The relationship between the members of a pair of stimuli simultaneously present has significance in "guiding" the behavior of the organism. Thus, the evidence offers support for gestalt-type concepts of discrimination learning and is opposed to associationistic theories such as those proposed by Hull and Spence.

Thus, if this research can be considered to embody processes fundamental to discrimination in general, learning of a discrimination problem is a function of the pattern of the stimuli; the learning process does not appear to be reducible to, nor can it be adequately discussed in terms of, separate and individual training to the absolute properties of simple stimuli. In terms of this particular research it seems that it is the relationship *between* the stimulus constituents of a pattern, rather than the individual properties *of* each stimulus constituent of the pattern, which is of significance in discrimination learning.

V. Summary

The problem. The present investigation attempted to obtain evidence regarding the adequacy of training in discrimination problems under (*a*) relational conditions, in which both the negative and positive stimuli were simultaneously present, and (*b*) under absolute conditions in which only one stimulus, either the negative or the positive, was displayed (but not both simultaneously). Gestalt theorists propose that discrimination is a relational process. Many behavior theorists, such as Spence, hold that discrimination is essentially a function of the number of reinforcements and nonreinforcements following reactions to each stimulus, i.e., that discrimination is a matter of developing positive response tendencies (habit strength) and negative response tendencies (inhibitory strength) to each stimulus, and discrimination is reducible to differential training with each individual stimulus component separately in an absolute fashion.

Subjects employed. Four groups of female rats were employed.

Group I (N = 8) These animals were given relational training with the brighter stimulus window as positive.

Group II ($N = 10$) These animals were given absolute training with the brighter stimulus window as positive.

Group III. ($N = 12$) These animals were given relational training with the dimmer stimulus window as positive.

Group IV. ($N = 12$) These animals were given absolute training with the dimmer window as positive.

Procedure. The *Ss* in Group I were trained until they reached the criterion of four successive days without error (ten trials per day). The *Ss* in Group II were trained by the absolute method and given as many (or more) trials to each stimulus as were required by the poorest *S* in Group I to attain the criterion. Then Group II *Ss* were tested with both stimuli present. The *Ss* in Group III were trained until they reached the criterion of four successive days without error (ten trials per day). The *Ss* in

Group IV were trained by the absolute method and given as many (or more) trials to each stimulus as were required by the poorest *S* in Group III to attain the criterion. Then Group IV *S*s were tested with both stimuli present.

Results. All Ss in the relational groups, Groups I and III, reached the learning criterion. The *S*s in Group II, on being tested by simultaneous presentation of the two stimuli, exhibited a strong preference to approach the brighter of the two lights. The *S*s in Group IV, on being similarly tested, also exhibited a strong tendency to approach the brighter of the two lights, despite the fact that they (Group IV) had been trained to go to the dimmer stimulus; none of them even remotely approached the learning criterion. Hence, regardless of whether animals subjected to the absolute method were trained to go to the brighter or to the dimmer stimulus, when both stimuli were presented simultaneously, all, with the exception of one animal who displayed a position response, preferred the brighter.

The results are interpreted to support the gestalt concept, i.e., that discrimination is based upon the "comparative" (or relational) aspects of the immediate component stimuli of the configuration, and that training upon the component stimuli separately is inadequate, at least less adequate, in producing efficacious discriminatory reactions.

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